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REMOTE OVERHEAD VIDEO EXTENDABLE ROBOT

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ABSTRACT

The Savannah River Plant (SRP) production of nuclear materials utilizes a waste storage farm, for radioactive waste products. The operation of the waste farm requires manipulation of piping and vessels within below ground pump pits, by overhead crane. A resultant potential exists for personnel exposure to radiation when any direct viewing is used to control crane operations.

The Savannah River Laboratory (SRL) has developed a Remote Overhead Video Extendable Robot (ROVER) as a means of reducing the exposure of personnel to nuclear radiation in the waste storage farm. ROVER has been developed, and turned over to the plant area for usage over the pump pits. All operation and control of ROVER are from a remotely located Video Van, located well away from the potentially hazardous operations.

BACKGROUND

Historically, personnel have been required to peek over the side of the radioactive pump pits and give hand signals to crane operators. The complexity of this task has also extended the time required to complete the movement of flow control "jumpers", replace equipment, and make inspections. Short-term efforts to supplement this with periscopes and temporarily rigged TV cameras

have met with limited success.

Preliminary work in the field demonstrated that overhead TV cameras could give good views of a work site, if a practical method of deployment and control could be developed. This early work used a "JLG" brand "cherry picker" manlift.

A program was begun to define the optimum vehicle and viewing methods. The most desirable support vehicle was determined to an electric powered device, to simplify its long term support at a field site. It was determined that it should be able to extend its camera assemblies at least 25 feet beyond its base. Additionally, all controls should be located remotely within the previously provided Video Support Van.

Multiple cameras with remotely controlled pan/tilt/zoom/focus/iris functions would be necessary to provide the required views, and to avoid obstructions. They should be deployable in positions offset from the centerline. This would provide angular views for depth perception. On-board lights should also be provided, to support night time operations. Optional features would include on-board microphones and loud speakers, all of which could improve operator to operator interface.

DESIGN CONCEPTS

Rover was designed to be a road driveable device, about the size of a small van, that "unfolds" into a highly elevated viewing platform. The unit is based on a modified electric, "Cherry Picker" manlift of a unique double-folding design, made by Genie Industries. ROVER is capable of deploying three TV cameras over a work area controlled by remotely located operators. (See figure 1)

Two cameras are in pods that can extend a maximum of 30 feet beyond the base of the device, to allow deployment over the work area, and up to 45 feet above. A third camera unfolds to a "Bird's-eye" view position an additional 10 feet above the camera pods, to a maximum of 55 feet from the ground.

ROVER will be driven to the work site from the attached basket from which the operator can also control all functions and initial deployment. The operator then attaches an umbilical cord from ROVER to the Video Van. He can control all functions from the Video Van, except the ground wheels.

The Video Van is located away from the hazardous area, and provides a safe and more efficient environment for both TV and crane control. Separate programs will move the controls of

both mobile and building cranes into this same van.

VEHICLE DESIGN DETAILS

Main Vehicle Design

A vehicle was chosen for the base of ROVER that was based on electrically powered hydraulics. A "manlift" device was selected from a variety of commercially available units. This provided a cost effective method of combining available technology with the specialized needs of this application.

The "Genie Lift" family of devices was initially selected because they offered all electric powered units, with high lift and long horizontal reach capabilities in a compact package. An additional, highly desirable, feature was that these units do not require support outriggers, when deployed.

The specific model chosen (X-45/22) combined 45 foot vertical and 22 foot horizontal reaches. These measurements related to the two man personnel basket attached to the end of the boom. In the final, camera boom, design the horizontal reach capabilities were extended to 30 feet beyond the base. (See figure 2)

A local design house (Accudraft Engineering Inc.) provided the camera platform design for ROVER per SRL specifications. The conversion of the vehicle was also done locally (Industrial Tool Inc.) under SRL direction. The final unit has been refined, checked out, and delivered to the field.

Removal of the basket and its 500 pound variable load requirement (i.e. two people and equipment), allow the horizontal reach of the unit to be extended without exceeding the vendors torque loading capacities. Subsequent experience has shown the vehicle to be stable without any outboard support.

The original "manlift" basket was relocated to the rear of the vehicle , to serve as a driving platform. It is now fixed at a comfortable driving height and provides a minimum of interference to boom movement. Limit switches were added to prevent accidental movement of the boom into the basket, when it is operated remotely. No control modifications were required, other than to reverse the direction of travel on the hand controls.

A new assembly was fabricated that attaches at the original basket attachment points, to support all of the added cameras, and deployment arms. This assembly is connected to the base and the video van through one added control cable and two high

intensity light power cables. These cables are placed in existing trays that traverse the multiple link arms.

Several small interface boxes were mounted on the base of ROVER, under existing fiberglass covers. The control interface is covered below.

Additional refinements to ROVER that are worth noting include a field modification to put mud type tires on the driven wheels to improve traction. These were not readily available, as the original "Genie Lift" used an odd rim size. Tires had to be made by recapping smooth type tires. An even more significant change was required to the boom rotational speed. The extension of the horizontal reach resulted in an unacceptably high tip speed at full extension and minimum control speed. Modifications to the vehicle hydraulics by the vendor have corrected this problem. (See figure 3)

ROVER Control Technique

The operator interface with ROVER was an important factor in producing a workable field system. A Video Van was supplied to the area in support of all video projects in this area. One portion of the Video Van controls were equipped to support ROVER.

The operator controls the two main camera assemblies on ROVER and all available motions of ROVER through three nearly identical controls. Familiar camera-like controls (i.e.pan/tilt/lens) were used to
control the boom swing, extend, and tilt functions. No provision was made for the operator to remotely drive ROVER for obvious safety considerations, and lack of need.

The interface between the remote controls and the existing vehicle controls was concentrated through a single electrical connection point. This simplifies troubleshooting and maintenance tasks. The three controls each connect to the vehicle through a single coaxial cable. An on-board interface box connects to each cable and controls one of the three units (i.e. cameras-2ea and vehicle-1ea).

Auxiliary functions were combined with the camera/ROVER control sets. This includes the on/off controls for the two 1000 watt lights, and deployment controls for the camera booms. A secondary boom also deploys straight up, to give a "birdseye view" of the other booms.

A few additional cables were added to support on-board microphones and speakers. One wire pair also protects the vehicle from inadvertent movement from the remote location by allowing lockout of all remote controls.

A on-board 110 VAC from 12 VDC inverter is used to supply a few units that require this voltage. This frees ROVER from any required services, other than the on-board batteries. The only exception to this is the need for a 110 VAC, 20 Amp, service for night time operation of the lights.

Camera Assemblies

Three camera assemblies are deployed over the work area and their respective booms can be deployed to the side and upward. The two of the assemblies, that are horizontally deployed, are fully equipped pan/tilt units with controllable zoom lenses. Each are controlled by one of the Video Van controls, including the horizontal boom on which each camera package is mounted. The latter unfold to each side of the main boom, to allow side by side deployment.

All three camera booms are powered by electric linear actuators. A four bar linkage is used with each of the two camera pods that move laterally. This maintains the camera orientation as the booms are moved. (See figure 4) When the lateral booms are perpendicular to the main boom they are at the maximum distance from each other of 20 feet. This aids in depth perception.

The third camera is a simpler assembly the unfolds upwardly, to about 10 feet above the others. It is the overview device. It is connected to the same control that controls ROVER's motions. Both are connected to the single third control in the Video Van. This control is also the one that controls the high intensity lights.

OTHER CONSIDERATIONS

Early work indicated the need for a practical method of transporting ROVER between areas and to some locations within the area. The combination of heavy vehicle weight (15,000 Lbs) and electric power source serve to limit its ability to negotiate inclines. A 20 degree incline is a practical limit it can handle. Most trailers of this capacity can not be used as the loading incline is too severe.

A special purpose trailer has now been supplied that is appropriately rated as to capacity and requires no more than a 15

degree incline.

SUMMARY

ROVER has provided SRP with a flexible device for overhead viewing of a variety of hazardous tasks, while protecting personnel from the potential of radiation exposure. A simple and user friendly interface allows remote control of the device with a minimal of field equipment. The visual information provided is expected to greatly enhance the ability to preform crane, and remote tasks. This will also improve our documentation and related training of such tasks.

The information contained in this paper was developed during the course of work under Contract No. DE-AC-76SR00001 with the U.S.Department of Energy.

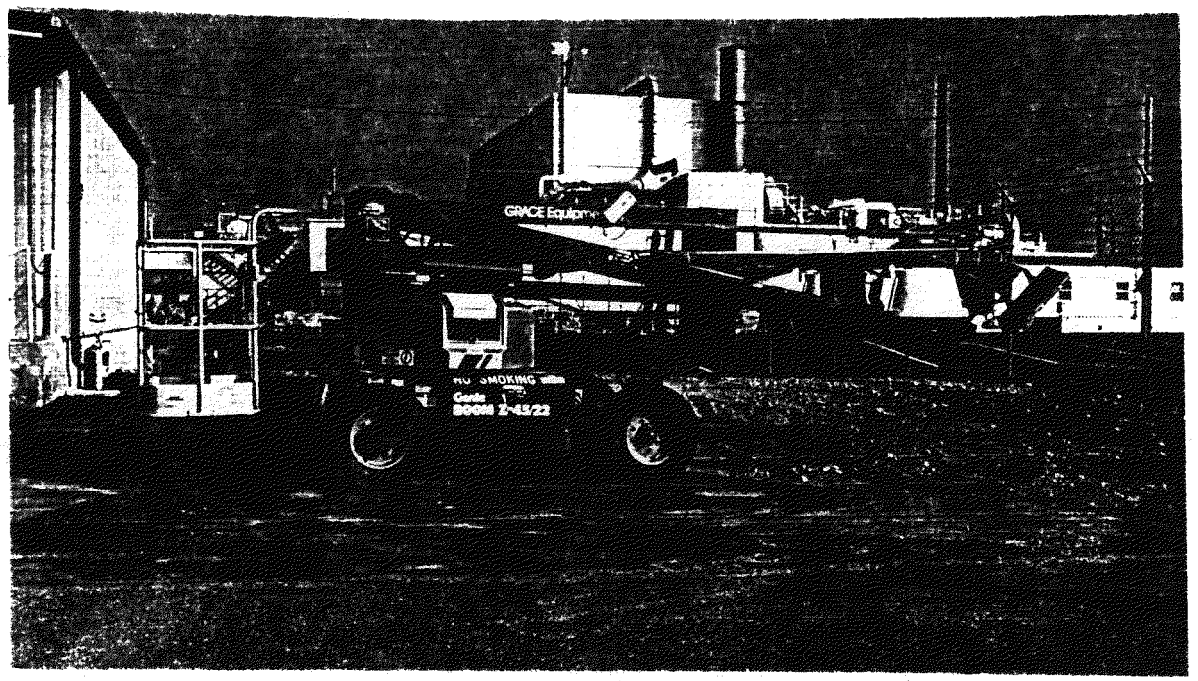

Fig.1. ROVER IN FOLDED POSITION

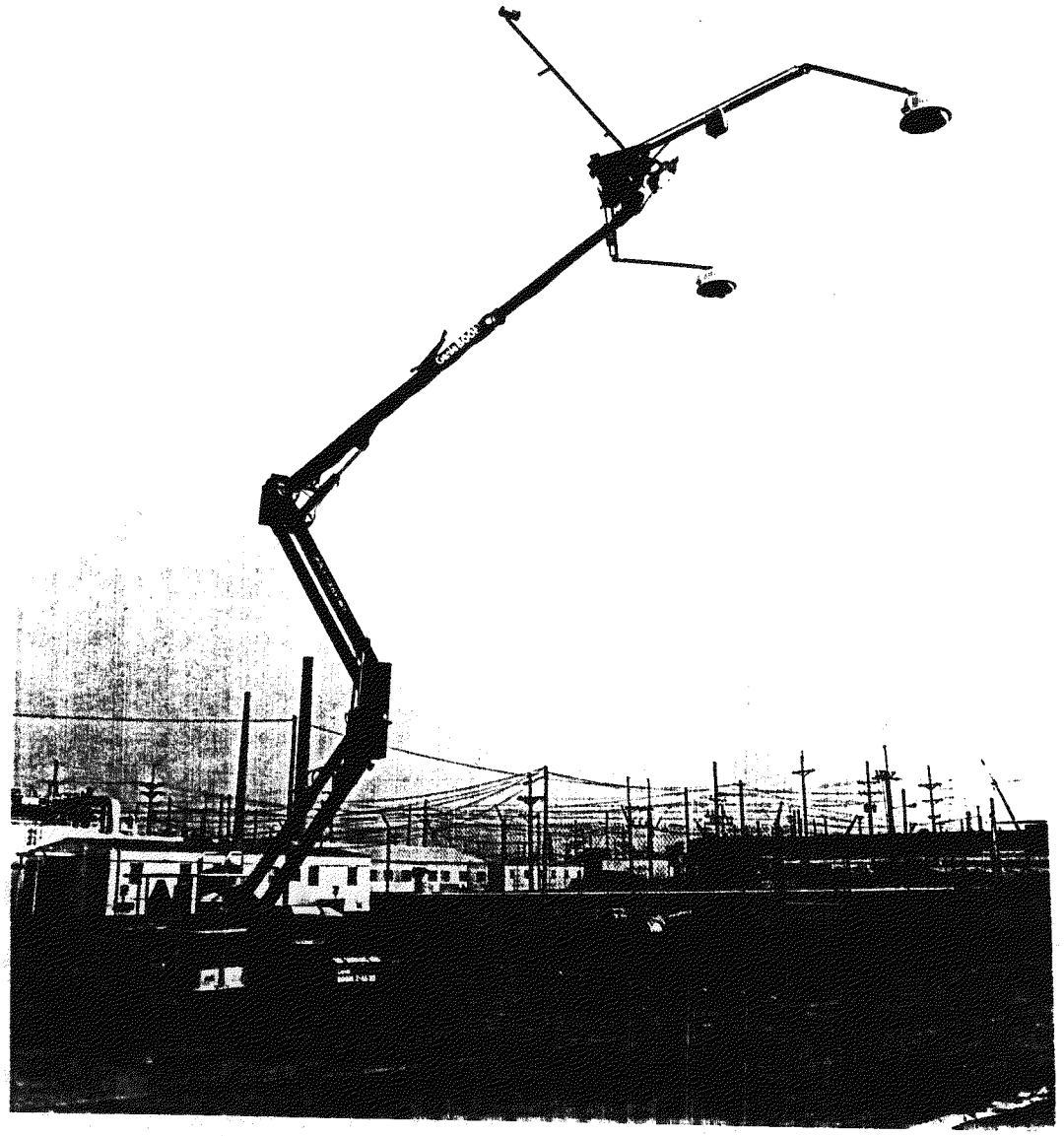

Fig.2. ROVER IN UNFOLDED - SIDE VIEW

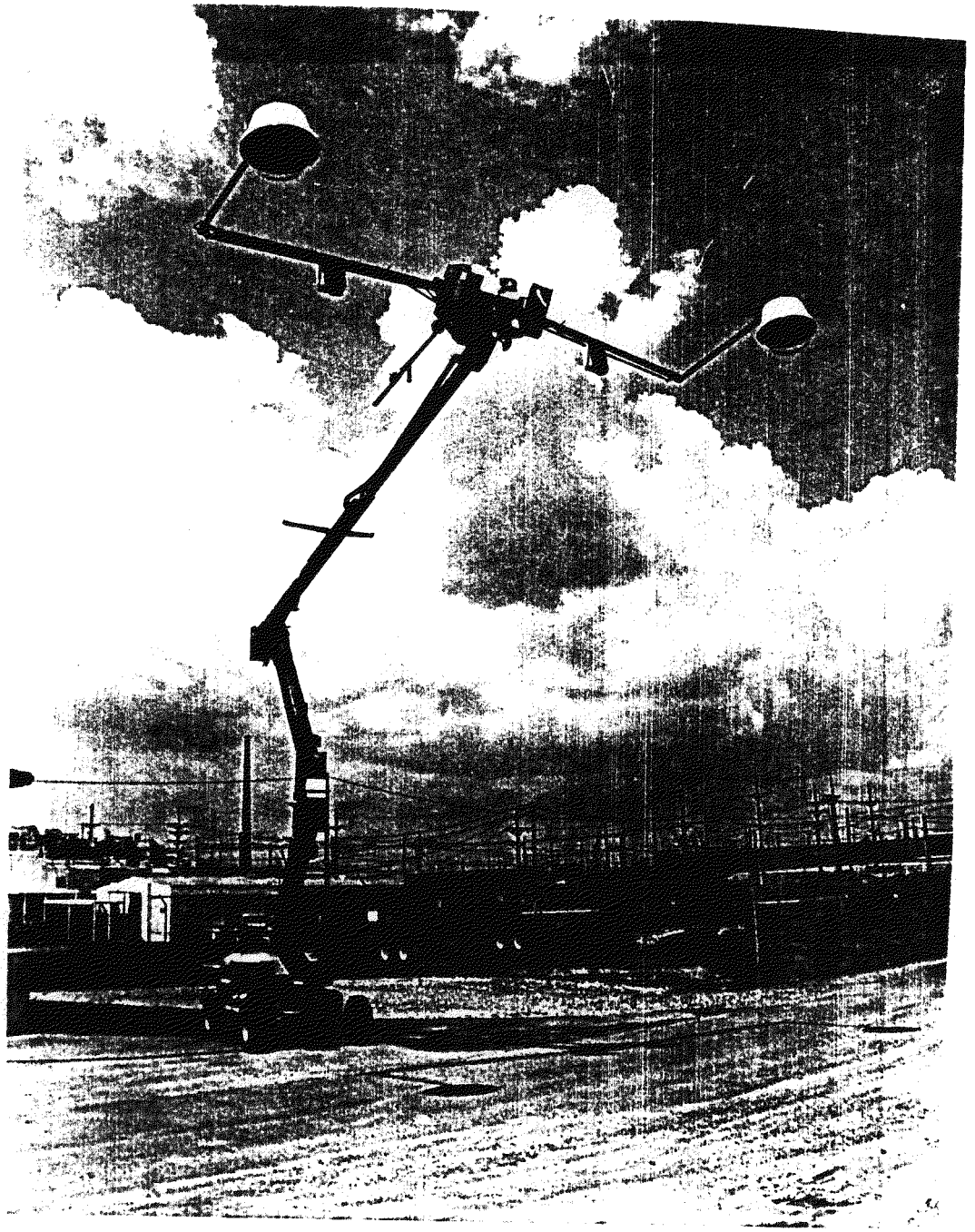

Fig.3. ROVER UNFOLDED - FRONT VIEW

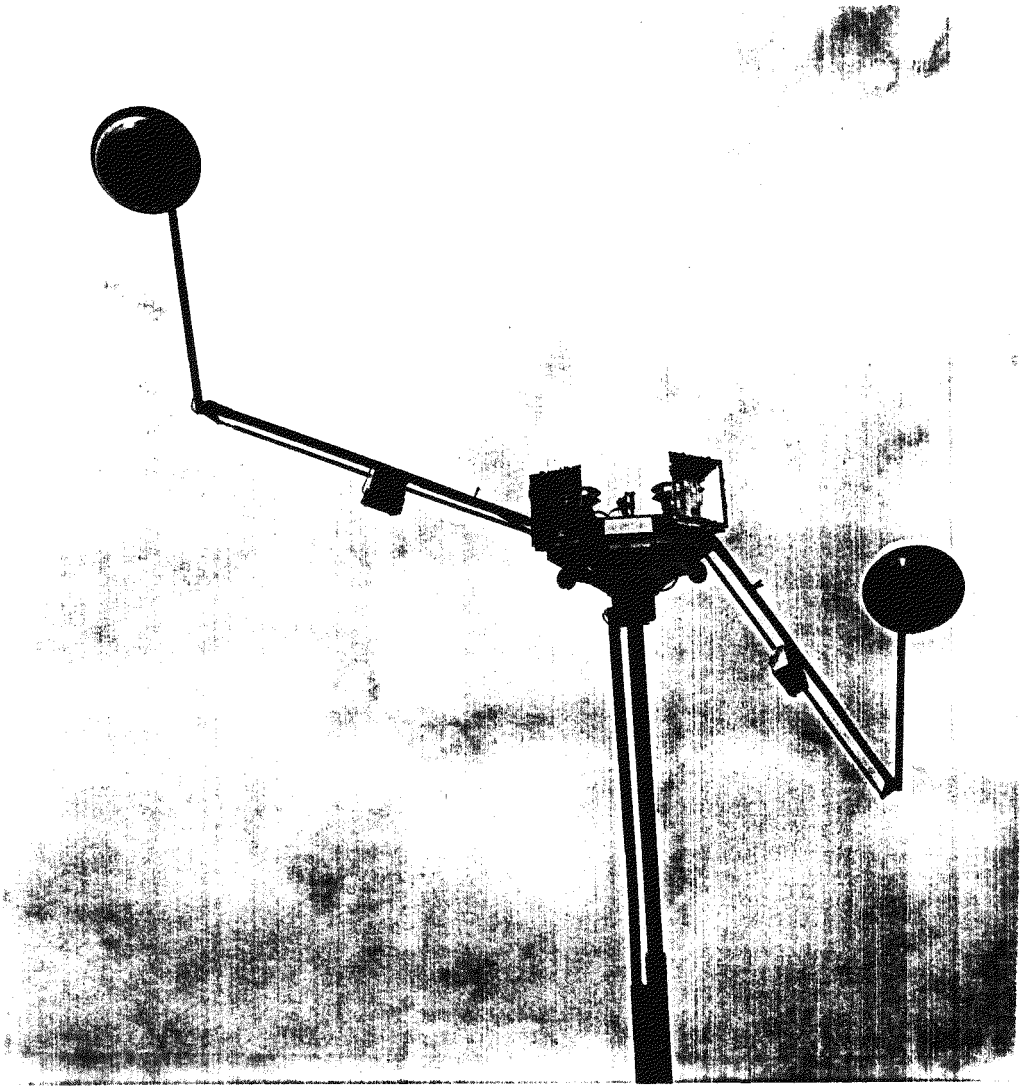

Fig.4. UPWARD VIEW OF CAMERA BOOMS